I. *The* Deſcription *and* Uſe *of an* Arithmetical Machine *invented by* Chriſtian-Ludovicus Gerſten, *F. R. S. Profeſſor of Mathematicks in the Univerſity of* Gieſſen. *Inſcribed to Sir* Hans Sloane, *Bart. Preſident of the* Royal Society. [*See* TAB. *Fig.* 1, 2, 3, 4, 5.]

SIR,

BEING at preſent on the Point of returning Home, I think myſelf obliged before my Departure, to return my humble Thanks to that Learned Body the *Royal Society*, over which you preſide, for the Honour they have lately done me, in chuſing me a Member; and to make a grateful Acknowledgment to you in particular, for the many Favours and Civilities, which, according to that amiable Character of Benevolence to all Strangers in general, you have been pleaſed to beſtow on me.

It is now a Duty incumbent on me to communicate to the *Royal Society* from time to time any thing new and curious, which may fall in my way: Therefore I now lay before them a Draught and Deſcription of an *Arithmetical Machine*, which I invented about twelve or thirteen Years ago.

Sir *Samuel Morland* was, for ought I know, the firſt who undertook to perform Arithmetical Operations by Wheel-work. To this end he invented two different Machines, one for *Addition* and *Subſtraction*, the other for *Multiplication*, which he publiſhed in *London*, in the Year 1673, in *ſmall*

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Twelves. He gives no more than the outward Figure of the Machines, and ſhews the Method of working them. But as by this every one, who has any Skill in Mechanicks, will be able to gueſs, how the inward Parts ought to be contrived ; ſo it cannot be denied, that theſe are two different Machines, independent of one another ; that the laſt, which is for *Multiplication*, is nothing elſe but an Application of the *Neipperian* Bones on flat moveable Disks ; conſequently that his Invention alone is not fit to perform juſtly all Arithmetical Operations.

After him the celebrated Baron *de Leibnitz*, the Marcheſe *Poleni*, and Mr. *Leupold* took this Undertaking in hand, and attempted to perform it after different Methods.

The firſt publiſhed his Scheme in the Year 1709, in the *Miſcellanea Berolinenſia*, but then he gave only the outward Figure of the Machine. Signor *Poleni* communicated his, but explaining at the ſame time its inward Conſtruction, in his *Miſcellanea* of the ſame Year, 1709. Mr. *Leupold*'s Machine, together with thoſe of Mr. *de Leibnitz* and Signor *Poleni*, were inſerted in his *Theatrum Arithmetico-Geometricum*, publiſhed at *Leipzig* in 1727, after the Author's Death, yet imperfect, as it is owned in the Book itſelf.

Beſides theſe, I learned from ſeveral *French* Journals, that *Charles Paſcal* invented one, which however I never had the ſight of.*

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* The Deſcription of this Machine is ſince printed by *M. Gallon* in his Collection of Machines and Inventions approved by the *Academy of Sciences* at *Paris* (publiſhed in *French* at *Paris*, 1735. in *Quarto*, in Six *Tomes*) in *Tom.* IV. *p.* 137 ; and likewiſe another by M. *Leſpine*, *Tom.* IV. *p.* 131 ; and three more by M. *Hellerin de Boiſliſſandeau*, *Tom.* V. *p.* 103, 117, & 121.

I took the Hint of mine from that of Mr. *de Leibnitz*, which put me upon thinking how the inward Structure might be contrived : But as it was not poſſible for me to hit upon the original Ideas of that Great Man, an exact Enquiry into the Nature of Arithmetical Operations furniſhed me at laſt with others, which I expreſſed in a rough Model of Wood, and ſhewed to ſome Patrons and Friends, who encouraged me to have another made of Braſs : But the want of an Artificer, able enough to execute my Ideas, made me delay it till the Year 1725 ; when having ſpare Time, and finding an Inclination to divert myſelf with Mechanical Operations, I ſet about it, and finiſhed the whole Work, fitted to a Reckoning not exceeding ſeven Places. And in *December* of the ſame Year, I had the Honour to lay this Machine before my Sovereign, the preſent Landgrave of *Heſſen Darmſtadt*, and the Hereditary Prince his Son, to whom I demonſtrated the Mechaniſm of the whole Invention.

I own that the gracious Reception it met with from both their Highneſſes, as well as the expreſs Recommendation of Mr. *de Wieger*, one of the Prince's Privy-Council, would have been powerful Inducements for me to have publiſh'd at that time an Account of my Machine ; but I was checked by the Uncertainty I was under, whether poſſibly Mr. *Leibnitz*'s Machine had not been brought to its Perfection ; in which caſe there is no doubt but the Operation of his Machine, if it would really perform what is promiſed in the Deſcription, would have been eaſier than mine, and conſequently preferable to it, provided its Structure did not prove too intricate, nor that the working of it took up too much time.

But at preſent, being certain that none of Mr. *Leibnitz*'s Invention has yet appeared in ſuch a State of Perfection, as to have anſwer'd the Effect propoſed, and that theſe of mine differ from all thoſe mentioned above, fancying at the ſame time, that Perſons who underſtand Mechanicks, will find it plain, practicable, and exact, in regard to its various Effects, I make no Scruple to preſent to the *Royal Society* this Invention, the Product of my younger Years indeed, but now with the ſeveral Amendments I have ſince added to it, as a Mark of the Reſpect and Veneration I have for this illuſtrious Body.

The Particulars of it are as follows:

There are as many Sets of Wheels and moveable Rulers as there are Places in the Numbers to be calculated. *Fig.* 1. ſhews three of them, by which one may eaſily conceive the reſt. A A ſhews the firſt Syſtem or the Figures of Unites, according to its inward Structure. B B and C C ſhews the ſecond and third Syſtem, *viz.* of Tens and Hundreds, according to their outward Form. We ſhall firſt conſider A A; where *α α α* is a flat Bottom of a Braſs Plate, which may be ſkrewed on either upon a particular Iron Frame, or only upon a ſtrong Piece of Walnut-Tree, doubled with the Grain croſs'd. In this Syſtem are two moveable Rules *gggg*, and *kkk*, the firſt of which I call the Operator, the ſecond the Determinator. There are beſides two Wheel-Works, the upper one is for *Addition* and *Subſtraction*, the lower one ſerves for *Multiplication* and *Diviſion*. The upper one is provided firſt with *a*, an oblique Ratchet-Wheel of 10 Teeth, of what Diameter you pleaſe, on which, however, depends the Length and Breadth of the Syſtem itſelf. This Wheel has a Stop *r*, with a depreſſing Spring *t*; Under the Wheel *a* is a ſmaller Wheel *b* of the ſame Shape: Both *a* and *b* are rivetted together, and fixed on a common Axis. Under the Wheel *b* lies a third *f*, which is a common Tooth-Wheel of 20 or more Teeth, according as one pleaſes: It is larger than *b*, and ſmaller than *a*, turns about the ſame Axis with the other two above it, and upon it is fixed a Stop *c*, with the Spring *d*, which catches the oblique Teeth of the Wheel *b*. Immediately under this Wheel lies the upper Part of the Operator, which may be beſt made of Iron or Steel. The Wheels may all be of Braſs, except the upper one. The Operator is of the ſame Thickneſs all over, and in its upper Part are fixed as many round Steel Pins as there are Teeth in the Wheel *f*, which are to catch the Teeth of this Wheel, and move it backwards and forwards. The Height of thoſe Pins ought exactly to anſwer the Thickneſs of the Wheel *f*. The Axis of the Wheels *a* and *b* is kept perpendicularly by the Bridge *ee*, which is ſkrewed to the Bottom, as appears by the Figure. The Operator *gggg* moves on the Side, above, and in the Middle in two Braſs Grooves *i i i* and *q q*; about D it jets out, on which Projection a Piece of Iron *h* muſt be well faſtened, having a ſtrong Pin, on which the Handle *z* fits, as you ſee in the Syſtem B B. The Side D itſelf ſlides in another Groove *s s*, and in its inner Corner joins to it the Determinator *k k k*, of the ſame Thickneſs with the Operator, the Shape of which is ſufficiently expreſſed in the Figure. This ſlides alſo up and down, on the one Side in the Groove *s s*, and *v* on the other Side, where it is ſmalleſt, in a ſmall Piece of Braſs *u*, and where it is broadeſt, above in the Operator itſelf, which is either hollowed out into another Groove, or filed off obliquely. The ſliding Part of the Determinator ought afterwards alſo to be fitted to it. Its chief Part is the Lock *u*, ſtanding perpendicular on its broad Part. I have drawn it ſeparately in *Fig*. 4. B B, in which the ſliding Stop *c*, which is preſſed down by its Spring *d*, but raiſed by the Tricker *a a*. That Tricker has a Pin *b*, on which is ſkrewed on the ſmall Handle *l l* (*Fig*. 1. in the Syſtems B B and C C.) In the Braſs Bottom A A (or *α α* *Fig*. 1.) you muſt file out 10 Ratchet-Teeth or Kerfs, purpoſely for the Stop of this Lock, or, which is better, you may inſert into the Braſs Bottom a ſmall Piece of Iron filed out according to this Figure. The Partition and Length of theſe Rachet-Teeth in the Bottom muſt fit exactly with the Circumference of the Wheel *f*, (*Fig*. 1. *Syſtem* A A,) with this Direction, that if the Lock is kept by the uppermoſt Tooth in the Bottom, the Operator cannot be moved at all; but when by preſſing down the Tricker *a a*, (*Fig*. 4) the Determinator is ſhoved down, and is ſtopp'd by the ſecond or third Tooth in the Bottom, the Operator being alſo drawn down as far as the Determinator permits, makes the Stop *c* (*Fig*. 1. *Syſt*. A A) ſlide over 1 or 2 Teeth of the ſecond Wheel *b*; conſequently the ſame Stop *c*, muſt ſlide over 9 Teeth, when the Lock of the Determinator will ſtand before the 10th Tooth in the Bottom, and the Operator is pulled down ſo far. If you have a mind to apply theſe Rachet-Teeth on the Outſide of the Plate ⊙ ⊙, that covers the Whole, you may fit the Lock to it accordingly: But in this Caſe the Covering-Plate muſt be well faſtened.

For *Multiplication* and *Diviſion*, there is properly in each Syſtem but one Wheel, likewiſe divided into 10 Rachet-Teeth, on which is rivetted the round Plate *l*, on which are engraved the Numbers or Figures: Theſe Wheels have no occaſion for any Bridge, but may turn about a ſtrong Pin of Steel, ſolder'd to the Bottom. The Rachet-Wheel *m m* reſts on one Side upon the Determinator, and upon a Piece of Braſs of the ſame Thickneſs, to which are faſtened the Stop *n*, and the Spring *p*. Upon the Operator is another Stop *o*, with its Spring; which Stop has a ſmall Arm at *o*, which is checked by a ſmall Studd, to hinder the Spring's preſſing the Stop lower down than it ought: By which Contrivance it is ſo order'd, that after the Operator is ſlid down ſo far as it can go, in being ſlid up again, the Stop *o* will turn but one Tooth of the Wheel *m m*. The round Plate *l* has in its Middle a ſmall hollow Axis, on which are turned firſt two Shoulders, and then a Skrew: This Skrew in the Syſtem A A is an ordinary one, winding from the left to the right.

But as each Syſtem ought to have Communication with the preceding one, though not with that which follows; to this end a projecting Tooth of Communication made of Steel ♂ is rivetted to the upper Plane of the uppermoſt Wheel *a*. This Tooth muſt be placed exactly on the Point of a Tooth of the Wheel, and by its Revolution catches and turns every time but one Tooth of the uppermoſt Wheel of the preceding Syſtem, ſliding over the following one (if there be any) without touching it. For this reaſon the Planes of the Braſs Bottoms in all the Syſtems ought to incline a little. This will beſt appear from the Vertical Section, *Fig.* 2. (cut in *Fig.* 1. in the Direction from ♄ to *f*) in which α is the Braſs-Bottom, HH the Wood-Bottom, *g* the Operator, *i* the Groove, *f* the third common Tooth-Wheel, *b* the ſecond Wheel, *a* the firſt or uppermoſt Ratchet-Wheel, *e* the Bridge, ⊙ the Covering-Plate, and ℘ the Tooth of Communication. I have repreſented all theſe Pieces of one Thickneſs; but every Artiſt will eaſily know where to add or take off.

Fig. 5. ſhews the Plan and true Diſpoſition of the Teeth in the ſeveral uppermoſt Wheels; that is to ſay, The Parallel Lines AB and CD ought always to cut the Braſs Bottoms (which are like one another in Length and Breadth) length-wiſe into two equal Parts: Then the perpendicular Interſection EF will determine the Centers *a* and *b*, of the two Wheels H and G. The Stop *r* ought every time to hold its Wheel in ſuch a manner, that the Points of two Teeth coincide with the Line AB or CD. The Obliquity of the Teeth is the ſame in both, with this difference however, that in G, which is a Wheel of the Syſtem AA, (*Fig.* 1.) they are cut in from the left to the right, but in H (a Wheel of the Syſtem BB) from right to the left. I need not take notice, that for making the Work more durable, the Teeth are not to be cut out into quite ſharp Points, but blunted a little, as in the Wheel H. The Nicety of the whole Machine chiefly conſiſts in placing the Center *a* and *b*, or (which amounts to the ſame thing) after having choſen the Breadth of the Braſs-Bottoms, in determining the Diameter of the uppermoſt Wheel: For if that ſhould prove ſo large, as that the two Wheels H and G ſhould very near touch one another, the Tooth of Communication will be ſhort, its Operation will be of a ſmall Force, and the Wheels themſelves will require a very great Exactneſs, leſt by turning about the Wheel H, and the Tooth of Communication ſtanding in the Poſition as it is repreſented in *Fig*. 5, a Tooth of the Wheel H may touch it, and ſtop the Motion. Whereas, on the other hand, ſuppoſing the Centers at the ſame Diſtance, and the Diameters of both Wheels leſs, the Tooth of Communication will be longer: then ſuch an Exactneſs is not requir'd in the Wheel, yet more Force is neceſſary for making the Tooth of Communication lay hold the better. Furthermore, it will be well for you to make the undermoſt common Tooth-Wheel as large as you can.

From the Conſtruction of this firſt Syſtem, with which the 3d, 5th, 7th, *&c.* entirely agree, one may eaſily imagine the 2d, 4th, 6th, 8th, *&c.* for every thing there alſo is the ſame, except only, that it is inverted; ſo that what in the firſt ſtands on the Right-hand, is on the Left in the ſecond.

The Plate for *Multiplication* has on its hollow Axis, as it is ſaid before, two Shoulders, the lowermoſt of which is very ſmall, the Sum of its Height, the Thickneſs of the Plate of the Wheel *m m*, and of the Operator muſt amount to as much as anſwers to the Heighth of the Bridge *ee*. On both Ends of the Braſs-Bottoms, the two Piece of Braſs ☾ ☾, of the ſame Height, are rivetted on. This being done, at laſt the Covering-Plates ⊙ ⊙ is prepared and skrewed on the Piece of Braſs ☾ ☾.. If the Machine be made pretty large, the Covering-Plate muſt be skrewed faſt, not only to the Bridge *ee*, but alſo not far from the Wheel of Multiplication. It muſt be provided not only with round Holes, through which are to go the Axis of each uppermoſt Wheel *a*; and the hollow Axis of the Plate *l*; but it muſt alſo have a long Slit, in which the Operator and Determinator may be moved up and down, and laſt of all a ſmall Window over the Plate of *Multiplication*, through which the Figure or Number engraved on the Plate may appear diſtinctly. To the projecting Skrew *l*, of the Plate *l*, is fitted an Handle *ff*, joined to an Index in the Shape of a Scythe. The Skrew in the Syſtem A A is a common Skrew, conſequently the Roundneſs of the Scythe muſt turn from the left to the right; but in the Syſtem BB, where it ought to be inverted, like all the other Parts, the Scythe muſt turn from the right to the left, as in the Figure. The Uſe of this is to ſhew which Way the Wheels are to be turned; and the Skrews are to prevent the Machine's being hurt by unskilful Hands.

On the Side of the Determinator, *viz.* on that Piece which cannot be preſſed down, is alſo skrewed a ſmall Index, which may be directed to ſuch Numbers or Figures as is required. Theſe Figures are to be engraved in the Covering-Plate, according

to

to the Figure, and their Diſtance depends on the Ratchet-Teeth *e e* (*Fig.* 4.) in the Braſs-Bottom.

On the Axis of each uppermoſt Wheel *a* (which Axis muſt be made ſquare as far as it projects over the Covering-Plate) is fixed a thin round Silver-Plate *x x* (in the Syſtems BB and CC) or *a d* in *Fig.* 3. yet ſo that it may not rub againſt the Covering-Plate. It has a hollow Axis *b c* (*Fig.* 3.) on which is a right or left Skrew, according to the Syſtem it belongs to, and a ſmall Shoulder *c*. To the Skrew is skrewed the Handle *ſ s* (Syſtem BB and CC, *Fig.* 1.) which is vertically flat on the Extremity, in order to turn by it the Plate and the Wheels. The Plate (as appears by the Figure) is divided by 3 concentrick Circles into two Rings, in the outmoſt of which are engraved the Numbers for *Addition*, in the inmoſt thoſe for *Subſtraction*. I will hereafter call this Plate only the *Silver-Plate*, the firſt Ring the *Addition-Ring*, the ſecond the *Subſtraction-Ring* : Moreover two Indexes *w* and *y* are skrewed to the Covering-Plate; *w* ſhews the Numbers of the outmoſt or *Addition-Ring*, and *y* thoſe of the *Subſtraction-Ring*. They have Hinges, that they may be lifted up, and the *Silver-Plate* taken out or put in again : Their Curvature ſerves for a Direction, which way the Plates ought to be turned. A skilful Artificer will be able to give them a neater and handſomer Shape, than here in the Draught, where I would not cover the Numbers.

All this being done, there remains now the Figures or Numbers to be engraved, in the manner following : Place each uppermoſt Wheel *a* (Syſtem AA) ſo, that the Tooth of Communication be ready to catch (as in G, *Fig.* 5) which may be eaſily felt. Obſerve in the Silver-Plate, where the Index *w* points, and there engrave the Number or Figure 9, lower down in the *Subſtraction-Ring*, where the Index *y* points, engrave the Cypher *o*. After this divide both Rings into 10 equal Parts, one of which is already deſigned for 9 in the *Addition*, and another for *o* in the *Subſtraction-Ring*; then obſerve which way the Wheel turns, if from the right to the left, as in Syſtem BB; then you muſt from the engraved Number 9 in the *Addition-Ring*, towards the right engrave *o* next, then 1, 2, 3, 4, *&c.* and in the *Subſtraction-Ring* towards the right alſo, from the already engraved *o*, firſt engrave 9, then 8, 7, 6, *&c.* *ordine inverſo*. But if the Wheel turns from the left to the right, as in the Syſtems AA and CC, you engrave the Numbers or Figures in the ſame Order, but from the right to the left (See in *Fig.* 1. the *Syſtems* BB and CC.)

In the *Multiplication-Wheels mm* you muſt conduct the Index *ff* exactly to the Window, as it is drawn in the Syſtem BB; mark the Place on the round *Multiplication-Plate* under the Window, and engrave upon it the Cypher or *o*: Then make, by two concentrick Circles, a Ring upon this Plate, and divide this Ring into ten equal Parts, and after the *o* (already engraved) engrave on the Numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, in the ſame Order as it was done in the *Addition-Ring* of the Silver-Plate of the ſame Syſtem. Laſt of all, if you think fit, you may ſkrew on thin Ivory Plates, to note upon them the Numbers which are to be calculated, particularly a long ſmall one on that Side of the Slit of the Determinator, where there are no Numbers, and alſo two ſhorter broader ones, one under the Window of *Multiplication*, the other above the Silver-Plate. All this together compoſes a Machine, by the help of which you may perform all the four Arithmetical Rules or Operations. The Way of working it, is as follows:

I. *As to Addition:* For inſtance, if you are to add 32 and 59; becauſe the hindmoſt Syſtem A A in the Figure, which ought to repreſent the Place of Unites, is not cover'd, let us take the Syſtem B B for the Place of the Unites, and the Syſtem C C for the Place of the Tens; turn the Silver-Plates *x x* in theſe two Syſtems, that the Indexes *w w* point to the two Numbers 5 and 9; then make the Determinators *ll*, *ll*, point alſo to 3 and 2: next take one of the two Operators, *ex. gr.* in B B, and pull it down as far as you can, and move it upwards again. This done, the Number 1 of the Silver-Plate in B B will come by this means under the Index *w*, and the Number 6 of the Silver-Plate in the Syſtem C C under its Index at the ſame time, which is 61, the Sum, 59 and 2. After this move the Operator of the Syſtem C C alſo up and down, when inſtead of 6, 9 will come under the Index; conſequently you have 91 under the Indexes *w w*, which is the Sum requir'd of 59 and 32 added together. The Reaſon of it is plain; for by pulling down the Operator of the Syſtem B B ſo far, the Stop *c* of the lowermoſt or common Tooth-Wheel *f* (*vid.* Syſt. A A) will ſlide over two Teeth of the Ratchet-middlemoſt Wheel *b*; and by moving the Operator up again, the ſame Stop *c* will turn the two Ratchet-Wheels *a* and *b* together, and cauſe the Stop *r* of the great or uppermoſt Wheel *a* to ſlide alſo over two Teeth; at the ſame time the Tooth of Communication *e* will move forward one Tooth of the uppermoſt Ratchet-Wheel in the Syſtem CC; conſequently on the Silver-Plate in BB, inſtead of 9 the Number 1, and in Syſtem CC, inſtead of 5 the Number 6 muſt appear under their Indexes *ww*; and ſo for the ſame reaſon, having pulled up and down the Operator of the Syſtem CC, the Number 6 pointed to by the Index muſt be at laſt changed into 9.

II. *Subſtraction.* Suppoſe 40 the Sum, from which you are to ſubſtract 24: Here you muſt put your Sum 40 in the *Subſtraction-Rings*; that is to ſay, turn the Cypher *o* in the Syſtem BB, and the Number 4 in the Syſtem CC, under the Indexes *yy*, as the Figure ſhews: Set the Determinators at 24, as in *Addition*; move alſo the Operators only once up and down, the Remainder 16 will appear under the Indexes *yy*. As for the Reaſon of this Operation, when you conſider, that the Numbers in the *Subſtraction-Rings* are engraved *inverſo ordine*, as it is ſaid before, you will find that it is the ſame as in *Addition*.

III. *Multiplication.* For inſtance; if you are to multiply 43 by 3, bring the *o* in all your *Addition-Rings* to the Indexes, as alſo in all your *Multiplication-Plates* in the Windows. Write down (which is more particularly neceſſary if the Numbers are larger than here) the Multiplicand 43 upon the Ivory-Plates near the two Determinators in the two Syſtems BB and CC: But the Multiplicator 3, you may write only on the Ivory-Plate under the

Window of the Syſtem B B. Set the Determinators at 43; then move your Operators ſucceſſively as often up and down, till there appears in both Windows the Number 3; then you will ſee on your *Addition-Rings* under the Indexes, the Product 129.

It is eaſy to underſtand, that as the *Multiplication* is nothing elſe than a repeated *Addition*, the Machine does alſo perform its Operation by a repeated *Addition* only: For the Number 3, which appears in the Window of the Syſtem B B, ſhews how many times you have added the Number 3, pointed by the Determinator to itſelf, which when done 3 times, is 9. And ſo the ſame Number 3, which appears in the Window of the Syſtem C C, after your Operation, ſhews how many times you have added the Number 4 to itſelf. I need not to make you obſerve, that beſides the two Syſtems B B and C C, there muſt be ſuppoſed another, not expreſs'd in the Figure, which will ſhew the Number 1 of the Product 129.

IV. *Diviſion.* If you are, for inſtance, to divide 40 by 3, ſet your Dividend 40 in the *Subſtraction-Rings* under the Indexes *y y*, in the Syſtem B B and C C; turn the Indexes *ff*, *ff*, near the Windows to make *o* appear; write your Diviſor near the Determinator of the Syſtem C C, and ſet the Determinator at 3; pull the Operator up and down, then you will have 1 under the Index *y*, and 1 likewiſe in the Window. By this you ſee, that you cannot work further in this Syſtem C C, becauſe you cannot ſubſtract 3 from 1: You muſt therefore go on, to the other Figure of the Dividend, *viz.* 0, and in the Syſtem B B ſet the Determinator again at 3.

This being done, the firſt pulling of the Operator up and down will produce 1 in the Window, and 7 in the *Subſtraction-Ring* under the Index, and the Number 1 which remained before in the Syſtem C C will be changed into *o*. Now as 7 is more than 3, you muſt work on accordingly; having done it twice more, you will find that there remains under the Index *y* but 1, (which is the Numerator of your Fraction) and below in the two Windows the Quotient 13. When you conſider that *Diviſion* is nothing elſe but a repeated *Subſtraction*, you will alſo eaſily underſtand the reaſon of this Operation.

Thoſe that underſtand the matter ever ſo little, may now eaſily conceive how they are to proceed with this Machine in larger *Examples*: However, for greater Clearneſs, I will explain it by two *Examples*.

Suppoſing there are ſix Syſtems, *a*, *b*, *c*, *d*, *e*, *f*; Let all the Numbers pointed to by the Indexes *ww* be in A B; thoſe which are to be pointed to by the Determinators, in C D; and thoſe which are ſeen in the Windows, in E F. Firſt of all, you muſt turn all your *Addition-Rings* of the *Silver-Plates* and your *Multiplication-Plates* to *o*; *viz.* that under all the Indexes *w w*, and in the Windows nothing may appear but *o*. Write the Number 3563 near the Determinator, in the Syſtems *a*, *b*, *c*, *d*, and direct them accordingly: The other Number 58, you muſt write down likewiſe, but under the Windows in Syſtem *a* and *b*, as you ſee in this Scheme.

	f	*e*	*d*	*c*	*b*	*a*	
A	0	0	0	0	0	0	B
C			3	5	6	3	D
E	0	0	0	0	0	0	F
					5	8	

Scheme. Move the ſeveral Operators, which are moveable, ſucceſſively as often up and down, till 8 appears below in the Windows, and you will have under the Indexes above 28504, the Product of 3563 × 8. And ſo the Numbers of the Machine will appear thus.

	f	e	d	c	b	a	
A	0	2	8	5	0	4	B
C			3	5	6	3	D
E	0	0	8	8	8	8	F
					5	8	

Next advance your Multiplicand 3563, from the Right to the Left; that is to ſay, place the Determinator in the Syſtem *b* at 3, in *c* at 6, in *d* at 5, in *e* at 3, and reduce every Number in the Windows to 0, except in the Syſtem *a*. See the *Scheme* following.

	f	e	d	c	b	a	
A	0	2	8	5	0	4	B
C		3	5	6	3		D
E	0	0	0	0	0	8	F
					5	8	

Then pull all the Operators again ſucceſſively in *b*, *c*, *d*, and *e*, up and down, till 5 appears in the Windows below, and you will find at laſt under the Indexes 206654, the Product of 3563 × 58.

	f	e	d	c	b	a	
A	2	0	6	6	5	4	B
C		3	5	6	3		D
E		5	5	5	5	8	F
					5	8	

But if you are to divide again 206654 by 3563, you muſt place the Dividend above in the *Subſtraction-Rings* under the Indexes. In the Windows below, every Figure muſt be 0, likewiſe as in the *Multiplication*; and write the Diviſor under the Dividend, according to *Vulgar Arithmetick*, and as in the *Figure* here annexed.

	f	*e*	*d*	*c*	*b*	*a*	
A	2	0	6	6	5	4	B
C		3	5	6	3		D
E	0	0	0	0	0	0	F

If you direct the Determinators in *e*, *d*, *c*, *b*, to their Numbers, and ſubſtract this Diviſor by pulling up and down the Operators as often as you can, you will have in the Windows in *e*, *d*, *c*, *b*, every where 5; but on the *Silver-Plates* there will remain 28504. Now advancing your Diviſor from the Left to the Right, bringing to the Windows in *d*, *c*, *b*, all the Cyphers 0, and operating as before, there will at laſt appear on the *Silver-Plates* nothing at all, but below in the Windows 5888. See the *Figure* following:

	f	*e*	*d*	*c*	*b*	*a*	
A	0	0	0	0	0	0	B
C			3	5	6	5	D
E		5	8	8	8	8	F

And here you have only this to obſerve, that in ſuch Caſes, you cut off all the hindermoſt Figures or Numbers in E F, except that which ſtands under the firſt Figure of the Diviſor; what remains is your Quotient.

As for what remains, if it be objected that this Machine cannot be fitted for ſo many and long

Numbers, as one would pleaſe, becauſe the Multiplication of ſo many Syſtems would require too great a Force for one Operator to move ſo many Wheels, kept by Springs, ſuppoſing the caſe that all the Teeth of Communication ſhould duly catch; I own that this Objection is but too well grounded: However, I cannot help obſerving at the ſame time, that this Defect can hardly be avoided, in any Arithmetical Machine, for performing all thoſe Operations of itſelf, without the help of the Mind: For there muſt certainly be a particular Syſtem for each Place of Figures, which is to communicate with the next; conſequenly, as the Syſtems encreaſe in Number, the Force muſt encreaſe alſo which is requir'd for moving them all. Beſides, it ought to be conſider'd, of what Size ſuch a Machine ought to be, which might ſerve for common Uſe. I think few Calculations could be required, for which 14 or 16 Syſtems might not ſuffice. That which I made was of 7 Syſtems, as I have already mention'd. The Diſpoſition of it was neither ſo well contrived as I have explained it here, nor were its ſeveral Parts ſo well wrought, as a good Artificer, who makes Profeſſion of ſuch Work, might have performed it; yet thoſe 7 Syſtems were very eaſily put in Motion; and if in a Machine for 14 Figures made by a ſkilful Hand, it could not be ſo eaſily practicable, this Defect, I believe, might be eaſily remedied, by applying the other Hand in the fifth or ſixth Syſtem to the Handle *ſs*, in order to eaſe and aſſiſt the Operator.

I am your humble Servant,

C. L. GERSTEN.

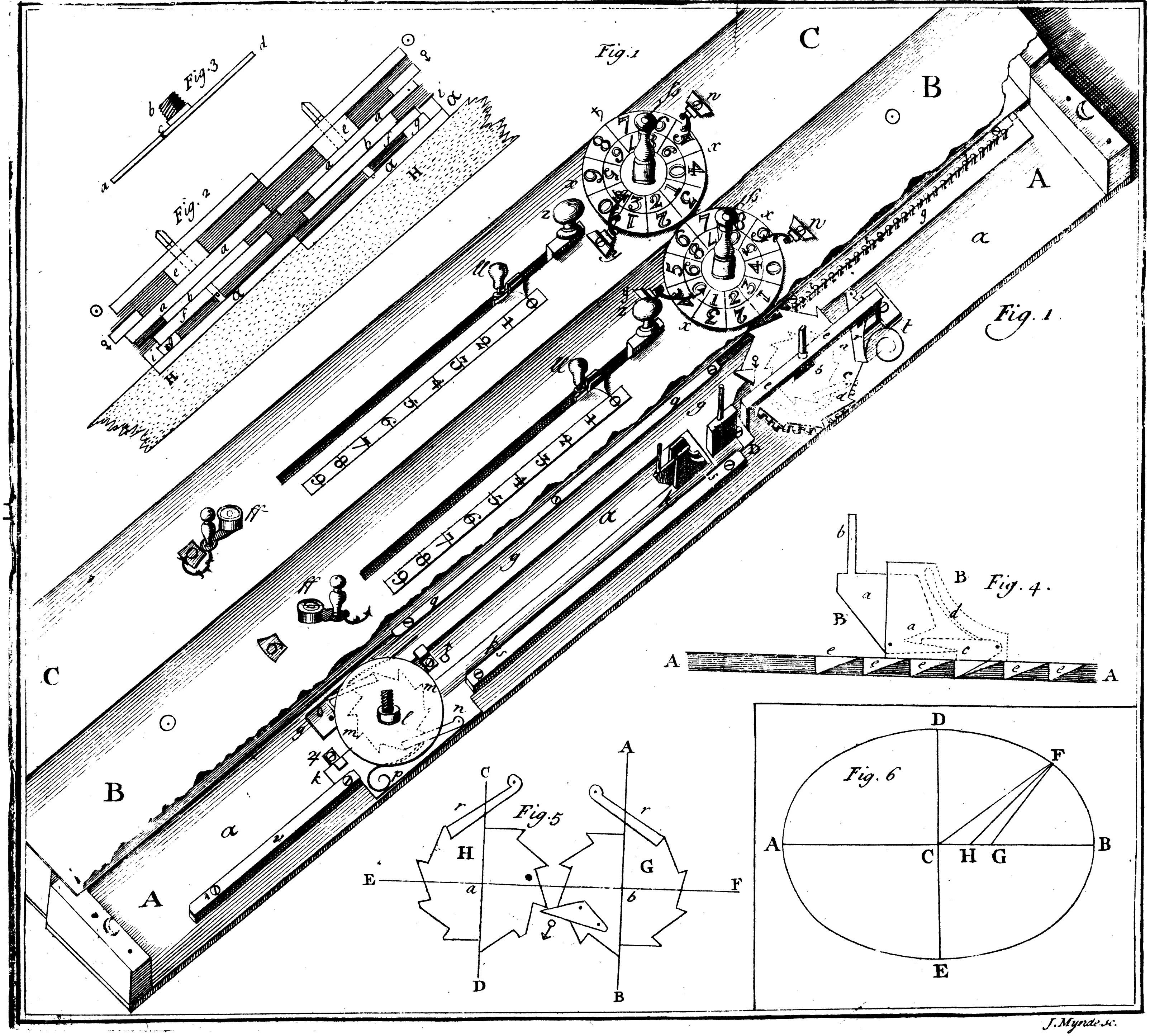
Fig. 1
C
B
A
α
g
n
x
z
ll
ff
t
k
l
m
p
D
Fig. 1
Fig. 2
H
a
b
e
f
g
i
Fig. 3
a
b
c
d
Fig. 4
a
b
B
c
d
e
A
A
Fig. 5
C
D
A
B
E
F
H
G
a
b
r
r
Fig. 6
D
F
A
C
H
G
B
E

J. Mynde sc.